A new rating scale for adult ADHD based on the Symptom Checklist 90 (SCL-90-R)

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ORIGINAL PAPER

A new rating scale for adult ADHD based on the Symptom Checklist 90 (SCL-90-R)

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Abstract Attention deficit hyperactivity disorder (ADHD) in adults is increasingly recognized as a clinically important syndrome. The aim of this study was to evaluate the psychometric performance of a new scale for adult ADHD based on the widely used Symptom Checklist 90 Revised (SCL-90-R). Scale performance was assessed in a clinical study including 100 ADHD patients and 65 opiate-dependent patient controls, and in the Zurich study, an epidemiological age cohort followed over 30 years of adult life. Assessments included a ROC analysis of sensitivity and specificity, internal consistency, test–retest reliability, external validity and measurement invariance over nine testing occasions. The new scale showed a sensitivity and specificity of 75 and 54%, respectively, internal consistency over 0.8 (McDonald's omega, Cronbach's alpha), one-year test–retest reliabilities over 0.7, statistically significant and substantial correlations with two other validated self-rating scales of adult ADHD ($R = 0.5$ and 0.66, respectively), and an acceptable degree of longitudinal stability (i.e., measurement invariance). The proposed scale must be further evaluated, but these preliminary results indicate it could be a useful rating instrument for adult ADHD in situations where SCL-90-R data, but no specific ADHD assessment, are available, such as in retrospective data analysis or in prospective studies with limited methodical resources.

Keywords ADHD · SCL-90-R · Rating scale · Adult

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Introduction

Although attention deficit hyperactivity disorder (ADHD) is now recognized as a chronic condition persisting into adulthood, it often remains undiagnosed in adults. This is due to the fact that adults manifest the disorder's core symptoms in different ways, making the diagnostic process difficult, a difficulty that is often compounded by different comorbidities. Currently, ADHD is thought to affect about one- to two-thirds of the affected children also in adulthood [7, 23]. A recent epidemiological study estimated the overall prevalence of adult ADHD to be around 4% [18, 19]. In childhood, boys are about three times more frequently affected than girls, whereas in adulthood, the sex ratio is more balanced [3, 4, 26].

Given its high persistence and the substantial impairment associated with the disorder in adulthood, as well as the widespread use of the SCL-90-R [11–13] as a self-report checklist of symptomatic complaints in psychiatric settings, it would be highly desirable to have a way of using the SCL-90-R as an indicator of the presence of ADHD. This possibility is attractive for re-analysis of data already collected and with subjects out of reach, but also for prospective analysis when a separate assessment of ADHD is not feasible or desired. This includes the important case where the SCL-90-R is used as a screening probe for the possible presence of ADHD, which, when positive, can be followed by a more specific assessment. Few existing studies administered the SCL-90 R as an outcome measure in adult ADHD [21, 30], but none of them have attempted to use it as a diagnostic tool.

We present here a scale formed from the item pool of the SCL-90-R that targets subjects exhibiting typical symptoms of adult ADHD such as inattention, hyperactivity and impulsivity. One aim of the present report was to

examine the suitability of the scale for diagnostic screening. A mixed clinical sample consisting of a group of confirmed ADHD patients and a control group of opiate-dependent patients were studied for this purpose.

As a further aim, the psychometric properties of the scale, particularly its temporal stability, that is, measurement invariance over time, were tested in an independent epidemiological sample from the Zurich study [2]. Loosely speaking, measurement invariance refers to a scale's measuring the same thing in the same way across different testing occasions. A simple example may serve: the Celsius scale measures temperature in intervals of one degree Kelvin, and the scale's origin (zero point) is the freezing point of water. Let us assume that we would like to measure and compare the temperature of a sample of water at different times. This comparison would only be meaningful if the measurement scale we used had the same intervals and zero points at each time, that is, if it were measurement invariant. If, for example, we used a Celsius scale at one time and a Fahrenheit scale at another, direct comparison of the measurements would obviously be non-sensical, since both zero points and intervals are different. Therefore, invariance of its measurement properties is a precondition for the stability of a scale and its meaningful use in comparing measurements obtained at different times. In psychometry, statistical methods from structural equation modeling are available to examine the degree to which a scale measures a certain construct (e.g., a personality trait or a psychiatric syndrome) reliably across different assessment times. Similarly as in the above examples, these methods assess the invariance of a scale's intervals and zero points over time.

The Zurich study is a longitudinal study of somatic and psychopathology in adults from the community, spanning over three decades from age 20 to 50. A diagnosis of adult ADHD to validate the proposed SCL-ADHD scale unfortunately is not available in the Zurich study, but full SCL-90-R data have been obtained nine times during the study period and so provide an ample database to examine the longitudinal characteristics of the proposed scale.

Materials and methods

Subjects

Study subjects were recruited from patients with a DSM-IV diagnosis of ADHD, consecutively presenting to the ADHD consultation service at the Center of Addiction Disorders, an outpatient facility of the Zurich University Psychiatric Hospital, between September 2000 and January 2006. Complete data could be obtained from 100 out of 134 patients presenting to the service [15].

Sixty-five control subjects without an ADHD diagnosis were recruited from opiate-dependent outpatients in methadone or buprenophine maintenance therapy at the Center for Addiction Disorders, in late 2005 [33]. Data on other kinds of medication are not available for these subjects.

Procedure

All diagnostic assessments were made in both the patient and the control group. A comprehensive diagnostic psychiatric evaluation was based on ICD-10 criteria [35]. However, ADHD was diagnosed according to the Utah criteria for diagnostic assessment with the Wender-Reimherr Interview (WRI) [34] translated to and validated for the German language by Rösler et al. and Retz-Junginger et al. [24, 25, 28, 32]. These are the only criteria explicitly formulated for adult ADHD and are compatible with DSM-IV-TR ADHD criteria. There are no criteria for adult ADHD in the ICD-10. Three ADHD subtypes were diagnosed according to DSM-IV-TR specifications: inattentive subtype, hyperactive subtype, and mixed subtype.

All patients and controls received the German versions of the Symptom Check List 90 Revised (SCL-90-R) [11, 12], the Wender Utah Rating Scale (WURS-k) [24, 25, 28] and the Attention Deficit-/Hyperactivity Self-Report Scale (ADHS-SB) [29], as part of the regular consultation.

In the case of unanswered questionnaire items, patients were approached again and asked to supply the missing information. When patients had difficulty answering a question, their therapist helped clarifying it, so that an answer could be arrived at. Auxiliary third-party information to support the diagnostic procedure was sought out for all patients, the main sources being family members, spouses, school reports, and childhood medical reports. Auxiliary information was more readily obtainable from ADHD patients than from control subjects.

Complete information for the SCL-90-R was obtained for 120 participants (66.2% controls, 77.0% ADHD patients; $P < .13$). 29 participants had only one missing item, 13 had more than one but less than ten missing items, and 3 had not filled out the questionnaire at all.

All subjects received a written description of the study procedure and gave their informed consent by signature. The study was approved by the local ethics committee.

Questionnaires

The Wender-Reimherr Interview (WRI) is the German version of the American Wender-Reimherr Adult Attention Deficits Disorders Scale (WRAADDS) for the assessment of adult ADHD. It allows a diagnosis of adult ADHD to be made. It contains seven scales for: attention difficulties, persistent motor hyperactivity, temper, affective lability,

emotional overreactivity, disorganization, and impulsivity. Each scale is represented by 3–5 items. A sum score is formed per scale, and each scale has a diagnostic threshold. A diagnosis requires that sum scores for scales 1–2 must each exceed their threshold and that for scales 3–7, 2 out of 5 sum scores must exceed their threshold.

The SCL-90-R is a self-report inventory of 90 symptoms that characterize various psychiatric conditions. The degree to which each symptom has been present in the past 7 days is rated on a Likert scale from 0 to 4, coded in the following way: 0 = not at all, 1 = a little bit, 2 = moderately, 3 = quite a bit, and 4 = extremely. The items can be grouped into nine scales: anxiety, depression, hostility, interpersonal sensitivity, obsessive–compulsive, paranoid ideation, phobic anxiety, psychoticism, and somatization. The scales are formed by summing up the ratings given to each item belonging to the respective scale. The SCL-90-R is customarily used to cover the past 7 days, but in the present study, it was used to cover the past 4 weeks.

The WURS-k is the German short form of the Wender Utah Rating Scale for the retrospective assessment in adulthood of childhood ADHD [25]. It is a self-rating instrument consisting of 25 items describing childhood symptoms of ADHD, only 21 of which are used to form the total score of the scale. The degree of endorsement of each item is rated on five levels as follows: 0 = not at all, 1 = slightly, 2 = moderately, 3 = distinctly, and 4 = strongly. The scale showed an internal consistency of 0.91 (Cronbach's alpha) [24] and a test–retest reliability of between 0.87 and 0.97 depending on the sample [25].

The ADHS-SB is a self-rating instrument for the assessment of adult ADHD in German [29]. It consists of 18 symptoms of ADHD derived from the DSM-IV and ICD-10 criteria for ADHD. The degree of endorsement is rated on four levels: 0 = not at all, 1 = slightly, 2 = moderately, and 3 = severely. The total score is obtained by summing up the 18 individual item scores. Subsyndrome scores for "attention deficit", "hyperactivity", and "impulsivity" can also be obtained. The internal consistency of the main scale is 0.9 (Cronbach's alpha) [29]. Total scores of the ADHS-SB and the WURS-k have been found to be statistically significantly correlated ($r = 0.58$) [29].

The ADHD scale of the SCL-90-R

Based on the Wender Utah Rating Scale as well as on clinical experience, nine items considered to be characteristic of adult ADHD were selected from the SCL-90-R. These included items 2, 9, 11, 24, 28, 55, 57, 74, and 78 (Table 3). A total score was formed by summing up the individual item scores. The possible range of scores is 0–36.

Assessment of psychometric properties of the SCL-ADHD scale in an independent epidemiological sample

The longitudinal behavior (measurement invariance/test–retest reliability) as well as the internal consistency of the SCL-ADHD scale were examined in an independent sample from a Swiss longitudinal community study, the "Zurich study". The Zurich study examines a wide range of somatic and psychic complaints in adults from age 19–20 to age 49/50, using a comprehensive structured interview applied by trained interviewers in participants' homes. Seven interview waves have been conducted so far, in the years 1979, 1981, 1986, 1988, 1993, 1999, and 2008. For the first interview wave, 591 participants were selected from a larger representative screening population consisting of all male conscripts to the army (age 19, $N = 2201$) and all women enrolled in the electoral register (age 20, $N = 2346$) in the canton of Zurich, Switzerland.

Sample selection followed a stratified sampling procedure, whereby the sample is enriched with cases at risk for the development of psychiatric and/or somatic syndromes. High risk subjects are defined by initial SCL-90-R total scores (Global Severity Index scores) above the 85th percentile and make up 1/3 of the sample, while the low risk group was randomly selected from subjects scoring below the 85th percentile in the SCL-90-R. The resulting sample consisted of 591 subjects (292 men, 299 women). Stratification bias can be removed by well-established statistical procedures to obtain population estimates [14]. The 591 subjects of the Zurich study thereby represent 2600 subjects of age 19–20 from the general population of the canton of Zurich.

The SCL-90-R was administered nine times during the study: every year from 1978 to 1981, as well as in the years 1986, 1988, 1993, 1999, and 2008 (note that the 1978 data were obtained from the initial screening sample which is not part of the regular interviews that started in 1979). Importantly, as in the clinical sample, the SCL was also used to cover the past 4 weeks, not just the past 7 days as is customary. Therefore, the SCL data of the clinical sample and the Zurich study are comparable in this respect.

Apart from examining the measurement properties of the scale, we also tentatively assessed sex differences in a group of potential ADHD subjects. These subjects were identified as those whose SCL-ADHD scores, averaged intra-individually over all nine measurement points, were equal to or above a cut-off value of 12 (which was independently established in a ROC analysis; see below). For the sake of simplicity, these subjects will be referred to as "SCL-ADHD high scorers". Given their tentative nature, these analyses will be reported mostly in a qualitative manner with only the core numerical findings being presented.

Statistical analysis

WURS-k, ADHS-SB, and SCL-ADHD total scores were compared across groups by Kruskal–Wallis tests. A receiver operating characteristic (ROC) analysis was used to compute the sensitivity and specificity of the SCL-ADHD scale to discriminate between a true and false ADHD diagnosis as established by DSM-IV-TR compatible criteria. The area under the ROC curve is reported as a global measure of the total discriminatory power of the scale. Cronbach's alpha [10] and McDonald's omega [27] served as indicators of the internal consistency of the scale. Correlations between different scales (SCL-ADHD, WURS-k, ADHS-SB) were based on non-parametric Spearman correlation coefficients.

In the Zurich study, the measurement properties of the SCL-ADHD scale were assessed in three ways: by examining (1) measurement invariance over time, (2) test–retest reliabilities, and (3) internal consistency. Measurement invariance over time refers to a scale measuring the same construct or content across different assessment times. This is important because if it does not, the scale scores measured at different times will not be comparable because they do have different meanings, that is, they do not relate to the construct in the same way. The scale is then not a reliable indicator of the underlying construct. The test–retest correlation is the correlation between the scale scores at two different assessment times and is another common indicator of trans-temporal scale reliability.

Finally, we examined internal consistency as the proportion of total scale variance due to both group factors and general factors. Together, they account for a scale's true-score variability, that is, the variability in the underlying construct the scale is intended to measure, as opposed to variability due to measurement error and confounding effects. This is what we, following Revelle and Zinbarg [27], call internal consistency. We report both McDonald's omega total (ω_t), a measure of internal consistency, and McDonal's omega hierarchical (ω_h), a measure only of the proportion of general (but *not* group) variability relative to total scale variability. We do not support Cronbach's alpha because it has been shown to have a number of serious shortcomings [36] that make it unsuitable as an index for internal consistency. We merely report it for comparability with other studies.

Measurement invariance across time was tested in a series of exploratory and confirmatory factor analyses using structural equation modeling. The principle of invariance testing is to examine whether those parameters of a scale that reflect its measurement properties—mainly the factor loadings and the scale item intercepts—remain constant across different testing occasions. In the present case, the different testing occasions are the nine interviews conducted over a period of 30 years.

The present data are ordinal and non-normal and were estimated using a mean- and variance adjusted weighted least squares (WLSMV) estimator, since maximum-likelihood (ML) estimation can lead to biased parameter estimates in skewed categorical data [6]. Correspondence of the model to the data was assessed using chi-squared testing as well as a series of commonly used statistical indexes with recommended cut-off values indicating good model fit: the comparative fit index (CFI; cut off $\geq$ 0.95), the Tucker-Lewis index (TLI, cut off $\geq$ 0.95), and the root mean square error of approximation (RMSEA, cut off $\leq$ 0.05). Differences in model fit between two successive CFA models were assessed using chi-squared tests and comparisons of fit indexes [6]. However, there are no agreed-upon standards for how to assess differences in model fit with either method. Both the chi-squared test [6] and the chi-squared *difference* test [5, 17] are known to be overly sensitive to sample size. There have been suggestions for how to use differences in a variety of fit indexes to compare the fit of two models [8, 9, 20]. Unfortunately, no recommendations for non-normal, categorical data are available. We will therefore tentatively follow the recommendation to consider differences in the CFI of 0.01 or less and in the RMSEA of 0.015 or less to indicate agreement between two models that have been obtained using ML estimation in multivariate normal data [8, 9].

Missing data were filled in by multiple imputation using an iterative Markov chain Monte Carlo (MCMC) method based on multivariate normal data. This method can be applied to categorical data using an approach involving dummy coding followed by rounding of the imputed data that was proposed by Allison [1]. Ten imputations were computed and included in subsequent analysis. Due to insufficient cell sizes in the highest item category of the SCL-90-R, the highest and second-highest categories were combined for purposes of multiple imputation and measurement invariance testing.

Some analyses in the Zurich study such as invariance testing were based on the stratified sample of 591 subjects; these analyses will be referred to as "stratified" or "unweighted". When population estimates were desired, sample stratification by risk group was offset using sampling weights as described by Dunn [14]. This well-established procedure yields population estimates of prevalence rates. This type of analyses will be referred to as "weighted".

Due to the small sample sizes, an analysis of ADHD subtypes was not attempted.

Analyses were carried out in Stata 11.1 [31] and Mplus 5.1 [22].

Results

Group characteristics

ADHD and opiate-dependent patients did not differ significantly in age and sex, but ADHD patients had higher levels of education and lower overall lifetime comorbidity, which was mainly due to the higher level of substance abuse in opiate-dependent patients. These results are summarized in Table 1.

Among the 100 ADHD patients, 26 belonged to the inattentive subtype, 7 to the hyperactive-impulsive subtype, and the majority, 67 subjects, to the mixed subtype. Information on current and past medication was available for 99 out of 100 ADHD patients. 70 patients received stimulants at the time of testing: 66 received methylphenidate, two d-amphetamine, and two modafinil (Table 2).

The SCL-ADHD scale in the two clinical groups

With the exception of item 24 ("temper outbursts"), all items of the ADHD scale were rated significantly higher by ADHD than by control patients (Table 3). Six of the ADHD items were among those eight (out of all 90) SCL items, showing the largest differences between ADHD and control group. The mean intra-item difference between the two groups across the 9 ADHD items was 0.64 (SD = 0.197). The mean SCL-ADHD total score was significantly higher among ADHD subjects (17.8, SD = 8.32) than among controls (11.8, SD = 7.12; $P < 0.001$).

SCL-ADHD scores were non-significantly higher among women than men, both in the total sample (16.8 vs 14.5; $P < .11$) and within the ADHD sample (19.4 vs. 16.5; $P < .09$). There were no sex differences within the control sample (11.8 vs 11.8, $P < .89$). Age did not differ between men (37.0 ± 10.11 years) and women (34.7 ± 10.33; $P < .22$).

Table 4 lists the sensitivities and specificities of all possible cut points on the SCL-ADHD scale with regard to the true DSM-IV-TR compatible diagnosis. A cut point of ≥12 yielded a sensitivity of 75% and a specificity of 54%. This means that for this cut point, the scale correctly identified 69 out of 92 true ADHD cases, leaving 23 false negatives (25.0%), and it correctly identified 33 out of 61 non-ADHD cases, leaving 28 false positives (46.0%). The total discriminatory power of the scale as indexed by the area under the ROC curve was 0.705. The scale had good

Table 1 Comparison of the ADHD and the patient control group (methadone-substituted opiate-dependent patients)

	Control	ADHD	*P*
N	65	100	
N women	22	42	
% women	33.9	42.0	.29
Age	34.5 (8.01)	37.2 (11.36)	.09
Education	%	%	.0001
School not completed	10.8	0	
Compulsory school	20.0	14.0	
Vocational school	36.9	30.0	
High school	0.0	26.0	
Technical university	3.8	18.0	
College/university	0.0	12.0	
Psychiatric lifetime comorbidity (ICD-10)	%	%	.0001
None	1.7	30.0	
Substance abuse	84.6	35.0	
Bipolar disorder	0.0	2.0	
Depressive disorder	20.0	26.0	
Mood disorder (total)	20.0	28.0	
Neurotic, stress-related, somatoform disorder	4.6	15.0	
Personality/behavioral disorder	16.9	8.0	
ADHD test scores	Mean (±SD)	Mean (±SD)	
WURS-k	28.4 (±18.26)	38.6 (±13.40)	.0001
ADHS-SB	16.0 (±11.91)	29.1 (±9.57)	.0001
SCL-ADHD scale	11.8 (±7.18)	17.8 (±8.32)	.0001

Table 2 Characteristics of the ADHD group

ADHD group ($N = 100$)	%
ADHD subtype	
Inattentive	26.0
Hyperactive-impulsive	7.0
Mixed	67.0
Stimulant medication	
Never	22.2
Past	8.1
Current	69.7
Antidepressant medication	
Never	53.1
Past	14.3
Current	32.7
Neuroleptic medication	
Never	90.9
Past	3.0
Current	6.1
Current medication	
None	15.2
Stimulants only	42.4
Antidepressants only	9.1
Stimulants + antidepressants	23.2
Stimulants + others	5.1
No stimulants	5.1

Table 3 SCL-90-R items selected for the ADHD scale and mean item scores for ADHD patients and opiate-dependent control subjects

Item number	Description	Control ($N = 65$)	ADHD ($N = 97$)	P
2	Nervousness or shakiness inside	1.52	1.97	.03
9	Trouble remembering things	1.49	2.02	.008
11	Feeling easily annoyed or irritated	1.58	2.23	.002
24	Temper outbursts that you could not control	1.13	1.47	.14
28	Feeling blocked in getting things done	1.65	2.31	.002
55	Trouble concentrating	1.45	2.55	.0001
57	Feeling tense or keyed up	1.40	2.08	.002
74	Getting into frequent arguments	0.72	1.37	.002
78	Feeling so restless you couldn't sit still	1.08	1.75	.003

internal consistency: Omega total (ω_t) was 0.90, omega hierarchical (ω_h) was 0.76, and Cronbach's alpha was 0.88.

SCL-ADHD scores correlated significantly with ADHS-SB scores (Spearman's Rho = .66, $P < .001$, Figure 1) and with WURS-k scores (Spearman's Rho = .50, $P < .001$). ADHS-SB and WURS-k also correlated significantly (Spearman's Rho = .62, $P < .001$).

Longitudinal stability of the SCL-ADHD scale in the epidemiological sample

Missing data

Due to a dropout rate of about 10% per interview, the proportion of missing values among SCL items increased from between 0.5 and 8% in 1979 to 45% in 2008. Overall, the average proportion of missing data was 26%.

Measurement invariance

The initial exploratory factor analysis (EFA) yielded a well interpretable and theoretically meaningful 3-factor solution (Table 5). The three factors were termed "nervousness", "impaired cognition", and "irritability", respectively. The model showed an excellent fit to the data ($\chi^2 = 23.4$, df = 11, $P = 0.016$; CFI = 0.994, TLI = 0.995, RMSEA = 0.015). Therefore, the following longitudinal measurement invariance testing was based on these three factors. Table 6 lists the series of models that were compared, each being more constrained than the preceding one. The first model tested for equality of factor structure across time, that is, the question whether the same items reliably load on the same factors in all interview years. This model fitted the data reasonably well. The following models successively added further constraints of measurement parameters across time: first, the equality of factor loadings and item intercepts, second, the equality of factor variances. As evident from Table 6, χ^2-difference testing indicated in each case that models were not invariant, whereas the fit indexes were all consistent with the models being invariant.

Table 4 Sensitivity and specificity of the SCL-ADHD scale for detecting adult ADHD, for all possible cut points of the scale

Cut point	Sensitivity (%)	Specificity (%)
≥0	100.0	0.0
≥1	100.0	3.3
≥2	100.0	4.9
≥3	98.9	6.6
≥4	97.8	9.8
≥5	95.7	16.4
≥6	93.5	23.0
≥7	90.2	26.2
≥8	87.0	34.4
≥9	84.8	36.1
≥10	80.4	44.3
≥11	75.0	45.9
≥12	75.0	54.1
≥13	72.8	54.1
≥14	64.1	62.3
≥15	63.0	67.2
≥16	57.6	73.8
≥17	54.4	75.4
≥18	51.1	80.3
≥19	46.7	80.3
≥20	44.6	86.9
≥21	37.0	86.9
≥22	33.7	86.9
≥23	30.4	90.2
≥24	28.3	91.8
≥25	25.0	91.8
≥26	19.6	95.1
≥27	19.6	96.7
≥28	17.4	98.4
≥29	13.0	98.4
≥30	9.8	100.0
≥31	6.5	100.0
≥32	4.4	100.0
≥33	3.3	100.0
≥34	1.1	100.0
>34	0.0	100.0

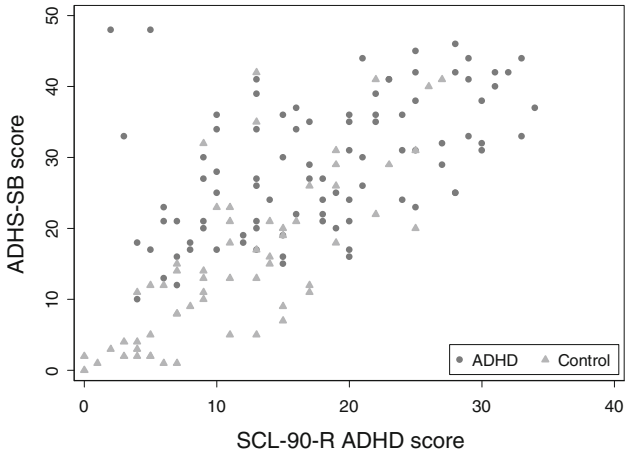

Fig. 1 Association between total scores of the ADHS-SB and the SCL-ADHD scale in a mixed sample of ADHD patients and opiate-dependent controls. Spearman correlation is 0.66, $P < .0001$

Table 5 Factor loadings from Exploratory Factor Analysis of SCL-90-R items selected for the SCL-ADHD scale

Item number	Description	Factor 1	Factor 2	Factor 3
2	Nervousness or shakiness inside	**0.74**	−0.03	−0.01
9	Trouble remembering things	−0.20	**0.73**	0.00
11	Feeling easily annoyed or irritated	0.19	−0.01	**0.58**
24	Temper outbursts that you could not control	0.30	0.06	**0.36**
28	Feeling blocked in getting things done	0.17	**0.46**	0.08
55	Trouble concentrating	0.01	**0.87**	−0.12
57	Feeling tense or keyed up	**0.80**	−0.01	0.00
74	Getting into frequent arguments	−0.01	−0.01	**0.77**
78	Feeling so restless you couldn't sit still	**0.43**	0.08	0.18

Numbers in boldface are primary loadings. Factors 1–3 were termed "nervousness", "impaired cognition", and "irritability", respectively

Test–retest reliabilities

For each factor, the correlation between successive interview times was obtained from the last model of invariance testing (the model imposing equality of factor variances). All factors showed a roughly linear decrease in test–retest reliability with time, due to the fact that the intervals between interviews became longer as the study progressed. For factor 1, correlations ranged from 0.45 (1999–2008) to 0.84 (1978–1979); for factor 2, they ranged from 0.53 (1988–1993) to 0.88 (1986–1988); and for factor 3, they ranged from 0.41 (1999–2008) to 0.81 (1978–1979). All factor correlations for all 1-year intervals were greater or equal to 0.7 (Fig. 2).

Table 6 Statistical results of measurement invariance testing

Model constraints[a]	χ^{2b}	df	P	CFI	TLI	RMSEA
Equal factor structure	639.4	675	0.001	0.931	0.969	0.037
Equal loadings & intercepts	197.0	73	0.001	0.926	0.965	0.040
Equal factor variances	638.3	118	0.001	0.919	0.961	0.042

CFI comparative fit index, *TLI* Tucker-Lewis index, *RMSEA* root mean square error of approximation

[a] Parameters were constrained to equality across assessment times

[b] Refers to the absolute χ^2 value for the first model (equal factor structure) and to the χ^2-difference to the preceding model for all other models

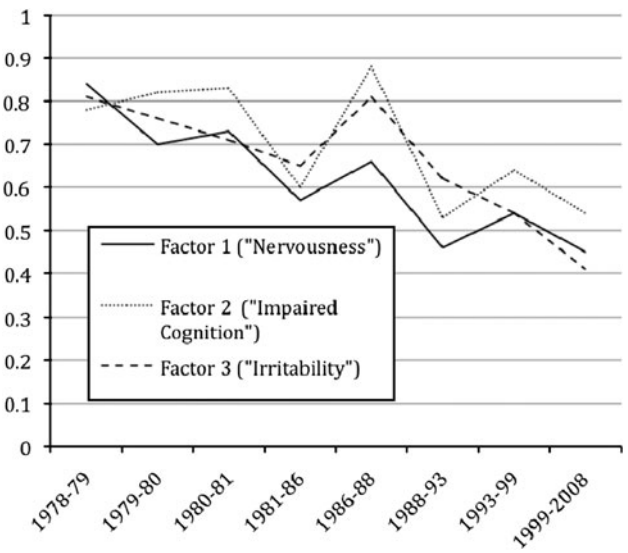

Fig. 2 Test–retest correlations for the three factors extracted from the SCL-ADHD scale

Internal consistency and reliability

Omega total (ω_t) was over 0.88 for all assessment years, while omega hierarchical (ω_h) varied between 0.66 in 1999 and 0.79 in 1979. Cronbach's alpha was over 0.83 for all assessment years, with a maximum of 0.86 in 1986.

Sex differences

In the unweighted (stratified) sample, there was a significant female preponderance of SCL-ADHD high scores in five out of nine interviews. The percentage of subjects showing ADHD scores ≥12 ranged from 56% at age 19 to 17% at age 50 among women and from 28% at age 20 to 11% at age

40 among men. Population estimates derived from the weighted sample yielded significant sex differences in three out of nine interviews, although prevalence rates in women (around 15%) were consistently, if only slightly, above those in men (around 8%). The average total prevalence of SCL-ADHD high scorers was around 11%.

Discussion

The present report introduces a new SCL-90-R scale for adult ADHD. The utility of the scale was evaluated in two ways: first, by computing its diagnostic performance in a mixed clinical sample consisting of confirmed ADHD cases and opiate-dependent non-ADHD cases; second, by assessing its psychometric properties, particularly its longitudinal stability, in the Zurich study, an epidemiological cohort of adults from the community that was followed over 30 years and for which nine assessments of the SCL-90-R are available.

In the clinical sample, the SCL-ADHD scale correctly identified 75% of true ADHD cases, giving a false negative rate of 25%. It correctly identified 54% of non-ADHD cases, giving a larger false positive rate of 46%. Its discriminatory performance was comparable to a similar SCL-90-R-based scale for mania proposed by Hunter et al. [16].

The nine SCL items selected for the scale at least partly cover the three subtypes of ADHD as specified in the DSM-IV: attention, hyperactivity, and impulsivity. Although an exact correspondence between these items and those of a specific adult ADHD scale like the ADHS-SB cannot be expected, the present SCL-ADHD scale does not leave out any relevant domain of impairment completely. Furthermore, the substantial (Rho = 0.66) and significant correlation between the SCL-ADHD and ADHS-SB sum scores is encouraging.

Our analyses indicate that the proposed scale represents a conceptually and empirically stable construct. Its internal consistency was good, according to three different indexes (one of which, Cronbach's alpha, we do not consider a trustworthy measure, however). It correlated substantially with two other validated ratings for adult ADHD (WURS-k and ADHS-SB). Its three factors "nervousness", "impaired cognition," and "irritability" replicated reliably across nine assessment times covering 30 years of adult life. The total scale proved to be quite stable longitudinally, justifying some confidence that it captures true changes in ADHD syndrome level over time, and not just measurement error and other artifacts. Although one of the tests (the χ^2-test) used to assess measurement invariance over time indicated a lack of stability, this test is known for its significant shortcomings, and its use in such contexts has been questioned [9]. We therefore base judgement of our scale's temporal stability on the comparison of fit indexes and on the high test–retest reliabilities found for all three factors ($r > 0.7$ for all one-year test intervals). However, it must be noted that the statistical assessment of longitudinal change in psychometric scales is very much a science in progress, and no final word on which approach is the best will be spoken soon. Therefore, results must be consumed with caution.

Tentatively assuming that subjects in the Zurich study with high average SCL-ADHD scores comprise an appreciable proportion of true ADHD cases, we examined sex differences with respect to this group. Sex differences in the proportion of SCL-ADHD high scorers were not consistently found. This is in line with the findings from the clinical sample showing non-significantly higher scores in women and with previous reports that sex differences in ADHD prevalence and symptom characteristics diminish in adulthood [4, 26].

The SCL-90-R is used worldwide and is available in many languages. One of its typical uses is in a clinical setting to assess the longitudinal course and outcome in treatment studies. More recently, it has also been integrated into epidemiological studies. Given this questionnaire's wide application, we believe that the proposed ADHD scale can be useful in clinical and research contexts. We can envisage at least two important scenarios: first, a researcher wishes to retrospectively assess an existing SCL-90-R data set, perform a rough identification of possible ADHD cases using our scale, and identify possible correlations with other variables of interest. This may even yield some added explanatory value, as when for example non-response in a medication study can be retrospectively accounted for by the previously undeteced presence of an ADHD syndrome in treatment-refractory patients. Second, a researcher planning a prospective study is limited by practical or substantive constraints to include a specific instrument for ADHD, but is able to include the SCL-90-R as a multipurpose instrument that will then allow, using our scale, to identify potential ADHD cases and explore possible interesting relations that might be followed up by more specific investigation. To further its utility, we present here full information on all cut points of the scale so that researchers and clinicians have the possibility to choose the cut point most useful to them depending on whether their emphasis is on sensitivity or specificity. We hope that the proposed scale can be further evaluated, specifically its discriminatory performance in various populations and its reliability and construct validity.

Limitations: The design of the proposed scale reveals its obvious limitations. The presence of ADHD is inferred from a very small item base. More seriously, neither the questionnaire from which the items are drawn nor the items itself were specifically selected to assess symptoms of ADHD. Undesired consequences would arise from taking

our scale as a replacement for an existing, ADHD-specific scale. It clearly is not.

With a sensitivity of 75% and a specificity is 54%, using the scale as a screening instrument will fail to identify 25% of true ADHD cases (false negatives), while a full 46% of non-cases will be falsely identified as ADHD cases (false positives). Therefore, while one use of the scale is to flag some subjects as potential ADHD cases, these subjects must then be followed up with a specific diagnostic instrument such as the WRI or the WRAADDS.

The proposed scale works by the principle that it is better to have some *limited* data than to have *no* data at all, provided the limited data are reliable. In this regard, the results for the proposed scale are certainly encouraging.

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Conflict of interest None.

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